OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BORON OXIDE

INTRODUCTION

This guideline summarizes pertinent information about boron oxide for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

B_2O_3

- **Synonyms**

Anhydrous boric acid, boric anhydride, boric oxide, boron sesquioxide, boron trioxide, diboron trioxide, fused boric acid

- **Identifiers**

1. CAS No.: 1303-86-2
2. RTECS No.: ED7900000
3. DOT UN: None
4. DOT label: None

- **Appearance and odor**

Boron oxide is a noncombustible, odorless, colorless or white, brittle substance that occurs as hygroscopic granules or in flake or powder form.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 69.6
2. Boiling point (at 760 mm Hg): 1,842°C (3,380°F)
3. Specific gravity: 2.5 at 20°C (68°F)
4. Vapor density: Not applicable
5. Melting point: 450°C (842°F)
6. Vapor pressure at 20°C (68°F): Approximately 0 mm Hg
7. Solubility: Soluble in ethanol, glycerol, and hot water; slightly soluble in cold water
8. Evaporation rate: Not applicable

- **Reactivity**

1. Conditions contributing to instability: Boron oxide reacts slowly with water to form boric acid.
2. Incompatibilities: Fires and explosions may result from contact of boron oxide with bromine pentafluoride or calcium oxide.
3. Hazardous decomposition products: None
4. Special precautions: None

- **Flammability**

This substance is not combustible.

1. Flash point: Not applicable
2. Autoignition temperature: Not applicable
3. Flammable limits in air: Not applicable
4. Extinguishant: Use an extinguishant that is suitable for the materials involved in the surrounding fire.

Fires involving boron oxide should be fought upwind and from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Firefighters should wear a full set of protective clothing (including a self-contained breathing apparatus) when fighting fires involving boron oxide.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

EXPOSURE LIMITS

• OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for boron oxide is 10 mg/m^3 (total dust) as an 8-hr time-weighted average (TWA) concentration [29 CFR 1910.1000, Table Z-1-A].

• NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for boron oxide of 10 mg/m^3 as an 8-hr TWA [NIOSH 1992].

• ACGIH TLV®

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned boron oxide a threshold limit value (TLV) of 10 mg/m^3 as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1991b].

• Rationale for limits

The limits are based on the risk of eye and upper respiratory tract irritation associated with exposure to boron oxide.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to boron oxide can occur through inhalation, ingestion, or skin contact.

• Summary of toxicology

1. *Effects on Animals*: Boron oxide is an irritant of the skin and mucous membranes in animals. The oral LD_{50} in mice is 3,163 mg/kg [NIOSH 1991]. Application of boron oxide dust to the shaved skin of rabbits caused redness that persisted for several days [Wilding et al. 1959]. When instilled into the eyes of rabbits, the dust caused conjunctivitis [Wilding et al. 1959]. Rats exhibited mild nasal irritation when exposed to a boron oxide aerosol at 470 mg/m^3 for 6 hr/day, 5 days/week for 10 weeks [NLM 1991; ACGIH 1991a]. Young rats intubated with a 10% boron oxide slurry for 3 weeks showed no adverse effects [ACGIH 1991a].

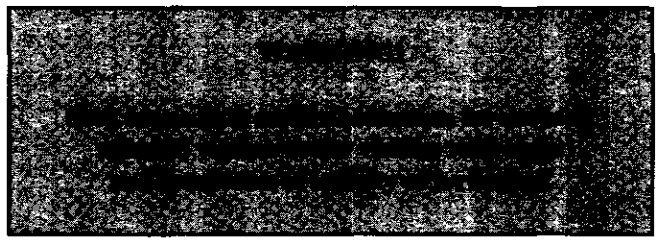
2. *Effects on Humans*: Exposure to boron oxide causes irritation of the eyes and respiratory tract; dryness of the mouth, nose, and throat; sore throat; and a productive cough [Garabrant et al. 1984]. A group of 113 workers exposed to the dust of boron oxide and boric acid at mean concentrations of 4.1 mg/m^3 (range 1.2 to 8.5 mg/m^3; exposures occasionally in excess of 10 mg/m^3) exhibited statistically significant increases in eye, nose, and upper respiratory tract symptoms [Garabrant et al. 1984].

• Signs and symptoms of exposure

1. *Acute exposure*: Acute exposure to boron oxide can cause pain and redness of the eyes, tearing, irritation of the nasal membranes, sore throat, and cough.

2. *Chronic exposure*: No signs or symptoms of chronic exposure to boron oxide have been reported.

• Emergency procedures



Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. *Eye exposure*: Irritation may result! ***Immediately and thoroughly*** flush the eyes with large amounts of water, occasionally lifting the upper and lower eyelids.

2. *Skin exposure*: Irritation may result. ***Immediately and thoroughly*** wash contaminated skin with soap and water.

3. *Inhalation exposure*: Move the victim to fresh air ***immediately***.

If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure*: Take the following steps if boron oxide is ingested:

—Have the victim rinse the contaminated mouth cavity several times with a fluid such as water.

—Have the victim drink a glass (8 oz) of fluid such as water.

—Induce vomiting by giving syrup of ipecac as directed on the package. If ipecac is unavailable, have the victim touch the back of the throat with a finger until productive vomiting ceases.

—Do ***not*** force an unconscious or convulsing person to drink fluid or to vomit.

5. *Rescue*: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve boron oxide and may result in worker exposures to this substance:

—Preparation of fluxes for enamels and glazes

—Laboratory analysis of silicates

—Manufacture of glass for heat-resistance

—Use of boron oxide in blowpipe analysis

—Application as a herbicide

—Production of surface coatings and use of boron oxide in the electronics industry

—Production of boron, boron master alloys, borides, metal borates, and boron carbide, nitrides, and halides

—Use of boron oxide as an additive to provide fire-resistance to enamels, paints, and insulation

—Use of boron oxide as an additive for glass fibers

The following methods are effective in controlling worker exposures to boron oxide, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety or health, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to boron oxide, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes and skin.

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to boron oxide at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with eye or skin diseases.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to boron oxide exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of boron oxide on the eyes or skin. Current health status should be compared with the

baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Serum borate concentrations are qualitative indicators of exposure to borate compounds (including boron oxide), but these levels cannot be correlated with airborne concentrations of borates. Therefore, no biological monitoring test acceptable for routine use has yet been developed for boron oxide.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of job placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne boron oxide is determined by using tared, low-ash polyvinyl chloride filters (5-micron). Samples are collected at a maximum flow rate of 2 liters/min until a maximum air volume of 960 liters is collected. This is a gravimetric field test method based on the total weight collected and does not need to be submitted to the laboratory for analysis. This method is described in the section on filter weighing procedures in the *OSHA Chemical Information Manual* [OSHA 1987]. Additional information can be found in Method 0500 of the *NIOSH Manual of Analytical Methods* [NIOSH 1984].

PERSONAL HYGIENE

If boron oxide contacts the skin, workers should flush the affected areas immediately with plenty of water for at least 15 min and then wash with soap and water.

Clothing contaminated with boron oxide should be removed promptly.

A worker who handles boron oxide should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, or using toilet facilities.

Workers should not eat, drink, or use tobacco products in areas where boron oxide or a solution containing boron oxide is handled, processed, or stored.

STORAGE

Boron oxide should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of boron oxide should be protected from physical damage, kept dry, and stored separately from bromine pentafluoride or calcium oxide, heat, sparks, and open flame. Because containers that formerly contained boron oxide may still hold product residues, they should be handled appropriately.

SPILLS

In the event of a spill involving boron oxide, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a spill.

1. Scoop up spilled material and place the material in a covered container for later reclamation or disposal.

2. Avoid generating dust during cleanup by using a vacuum or a wet method.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

Boron oxide is not subject to EPA emergency planning requirements [40 CFR 355.30].

- **Reportable quantity requirements for hazardous releases**

Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National Response Center of an accidental release of boron oxide; there is no reportable quantity for this substance.

- **Community right-to-know requirements**

Employers are not required by Section 313 of the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022] to submit a Toxic Chemical Release Inventory Form

(Form R) to EPA reporting the amount of boron oxide emitted or released from their facility annually.

- **Hazardous waste management requirements**

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Although boron oxide is not specifically listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limits. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of boron oxide exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective gloves and clothing should be worn to prevent repeated skin contact with boron oxide. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to boron oxide permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to boron oxide.

If boron oxide is dissolved in water or an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which boron oxide might contact the eyes (e.g., through dust particles or splashes of boric acid). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with boron oxide. Contact lenses should not be worn if the potential exists for boron oxide exposure.

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